A plurality of the array waveguides include an effective length tuner. Each effective length tuner is configured to change the effective length of an array waveguide. The effective length tuners are configured to change the effective length of the array waveguides such that the location where the light signal is incident on the output side of the light distribution component changes. The location can be changed such that the light signal is incident on a particular output waveguide.

A1

In some instances, the light signal is one of a plurality of light signals. The array waveguides are configured such that each light signal is incident on the output side at a different location on the output side. The effective length tuners are configured to change the effective length of the array waveguides such that the location where each of the light signals is incident on the output side of the light distribution component changes. The locations can be changed such one or more of the light signals are incident on an output waveguide. Accordingly, the light signal that appears on a particular output waveguide can be selected.

Please amend paragraph 60 as follows:

During operation of the filter 10, a light signal enters the first light distribution component 14 from the input waveguide 12. For the purposes of simplifying the discussion, the light signal is presumed to be a single channel light signal. The first light distribution component 14 distributes the light signal to the array waveguides 26. Each array waveguide 26 receives a fraction of the light signal. Each array waveguide 26 carries the received light signal fraction to the second light distribution component 18. A light signal fraction traveling through a long array waveguide 26 will take longer to enter the second light distribution component 18 than a light signal fraction traveling through a shorter array waveguide 26. Unless the effective length differential, ΔL, between adjacent array waveguide 26 is a multiple of the light wavelength, the light signal fraction traveling through a long array waveguide 26 enters the second light distribution component 18 in a different phase than the light signal fraction traveling along the shorter array waveguide 26.

A2

Please amend paragraph 70 as follows:

During operation of the filter 10, a first light signal from the input waveguide 12 is distributed to the array waveguides 26. The array waveguides 26 carry the light signal portions

A3

A3 cont'd

to the reflector 34 where they are reflected back toward the first light distribution component 14. The first light distribution component combines the light signal portions so as to re-form the light signal and converge the light signal at the output waveguide 16. As a result, the output waveguide 16 carries the re-formed light signal.

Please amend paragraph 72 as follows:

A4

Figure 1C illustrates another embodiment of a filter 10 having a single light distribution component and curved array waveguides 26. The filter 10 is included on an optical component. The edge of the optical component is shown as a dashed line. The edge of the optical component can include one or more reflective coatings positioned so as to serve as reflector(s) 34 that reflect light signals from the array waveguides back into the array waveguides. Alternatively, the edge of the optical component can be smooth enough to act as a mirror that reflects light signals from the array waveguide back into the array waveguide. The smoothness can be achieved by polishing or buffing. An optical component having a dispersion compensator according to Figure 1C can be fabricated by making an optical component having a filter 10 according to Figure 1A and cleaving the optical component down the center of the array waveguides. When the optical component is symmetrical about the cleavage line, two optical components can result. Because the light signal must travel through each array waveguide twice, each resulting dispersion compensator will provide about the same dispersion compensation as would have been achieved before the optical component was cleaved.

Please amend paragraph 74 as follows:

A5

The effective length tuners 28 are configured to change the effective length of each array waveguide 26 by a different amount. The difference in the amount of effective length change between adjacent array waveguide 26 is the effective length change differential, δl. The effective length tuners 28 are configured so the effective length change differential, δl, is a constant for adjacent array waveguides 26. More specifically, the value of the effective length change differential, δl, is the same for different pairs of adjacent array waveguides 26. When the effective length change differential, δl, is a constant, the value of the effective length differential, ΔL, changes.

Please amend paragraph 77 as follows:

A6

Figure 2A through Figure 2C illustrate operation of the filter so a particular channel appears on the output waveguide 16. Figure 2A illustrates the location where a first channel labeled A and a second channel labeled B each are incident on the output side 22 of the second light distribution component 18 when the effective length tuners 28 are not engaged. Each of the channels is incident on the output side 22 above the output waveguide 16. As a result, neither channel appears on the output waveguide 16.

Please amend paragraph 80 as follows:

A7

The filter can include more than one output waveguide 16 as shown in Figure 2D. The filter includes an output waveguide 16 labeled X, an output waveguide 16 labeled Y and a plurality of channels labeled A through D. The ports 29 of the output waveguides 16 are spaced at about the channel spacing. The channel spacing is about equal to the spacing between the locations where the channels are incident on the output side 22. As a result, each output waveguide 16 can carry a different channel. Further, the channel spacing remains substantially constant as the channels are shifted. As a result, the channels can be shifted so each of the output waveguides 16 carries a different channel than it carried before. For instance, the output waveguide 16 labeled X is illustrated as carrying the channel labeled B and the output waveguide 16 labeled Y carrying the channel labeled D. However, the effective length tuners 28 can be operated so the output waveguide 16 carry different channels. For instance, the output waveguide 16 labeled X can carry the channel labeled A and the output waveguide 16 labeled Y can carry the channel labeled C.

Please amend paragraph 83 as follows:

A8

Figure 3A illustrates a suitable construction for an optical component having a filter 10 according to the present invention. A portion of the filter 10 is shown on the component. The illustrated portion has a first light distribution component 14, an input waveguide 12 and a plurality of array waveguides 26. Figure 3B is a topview of an optical component having a filter 10 constructed according to Figure 2A. Figure 3C is a cross section of the component 36 in Figure 3B taken at any of the lines labeled A. Accordingly, the waveguide illustrated in Figure

A8 cont'd

3C could be the cross section of an input waveguide 12, an array waveguide 26 or an output waveguide 16.

Please amend paragraph 85 as follows:

A9

The component includes a light transmitting medium 40 formed over a base 42. The light transmitting medium 40 includes a ridge 44 that defines a portion of the light signal carrying region 46 of an input waveguide 12, an array waveguide 26 or an output waveguide 16. Suitable light transmitting media include, but are not limited to, silicon, polymers, silica, SiN, $LiNbO_3$, GaAs and InP. As will be described in more detail below, the base 42 reflects light signals from the light signal carrying region 46 back into the light signal carrying region 46. As a result, the base 42 also defines a portion of the light signal carrying region 46. The line labeled E illustrates the profile of a light signal carried in the light signal carrying region 46 of Figure 3C. The light signal carrying region 46 extends longitudinally through the input waveguide 12, the first light distribution component 14, each the array waveguides 26, the second light distribution component 18 and each of the output waveguides 16.

Please amend paragraphs 88 as follows:

A10

The array waveguides 26 of Figure 3B are shown as having a curved shape. A suitable curved waveguide is taught in US Patent Application serial number 09/756,498, filed on January 8, 2001, entitled "An Efficient Curved Waveguide" and incorporated herein in its entirety. Other filter 10 constructions can also be employed. For instance, the principles of the invention can be applied to filters 10 having straight array waveguides 26. Filters 10 having straight array waveguides 26 are taught in US Patent Application serial number 09/724,175, filed on November 28, 2000, entitled "A Compact Integrated Optics Based Arrayed Waveguide Demultiplexer" and incorporated herein in its entirety.

Please amend paragraphs 95 and 96 as follows:

A11

The above discussion presumes that a substantially constant ΔL_{ELT} is preserved. However, when the effective length tuners 28 are configured so the change in effective length per unit of effective area 50 is about the same for each effective length tuner 28, the same result

can often be achieved by arranging the effective length tuners 28 so the difference in the effective area 50 for adjacent array waveguides 26 is a constant.

A variety of effective length tuners 28 can be employed with the arrayed waveguide grating 24. A suitable effective length tuner 28 changes the index of refraction of the light transmitting medium 40. When the index of refraction of an array waveguides 26 increases, a longer time is required for the light signal to travel through the array waveguide 26. As a result, the array waveguide 26 is effectively longer. Alternatively, when the index of refraction of an array waveguides 26 decreases, a shorter time is required for the light signal to travel through the array waveguide 26. As a result, the array waveguide 26 is effectively shorter.

A11 cont'd

Please amend paragraphs 110 - 126 as follows:

The effective length tuners 28 can also include a set of electrical contacts. Figure 7A is a topview of a component 36 having effective length tuners 28 including a first electrical contact and a second electrical contact. Figure 7B is a cross section of the component 36 shown in Figure 7A taken at the line labeled A. The effective length tuners 28 include a first electrical contact 64A positioned over the ridge 44 and a second electrical contact 64B positioned under the ridge 44 on the opposite side of the component 36. A doped region 66 is formed adjacent to the first electrical contact 64A and the second electrical contact 64B. The doped regions 66 can be N-type material or P-type material. When one doped region 66 is an N-type material, the other doped region 66 is a P-type material. For instance, the doped region 66 adjacent to the first electrical contact 64A can be a P type material while the material adjacent to the second electrical contact 64B can be an N type material. In some instances, the regions of N type material and/or P type material are formed to a concentration of $10^{(17-21)}$ /cm^3 at a thickness of less than 6 μm, 4 μm, 2 μm, 1μm or .5 μm. The doped region 66 can be formed by implantation or impurity diffusion techniques.

A12

During operation of the effective length tuner, a potential is applied between the first electrical contact 64A and the second electrical contact 64B. The potential causes the index of refraction of the first light transmitting medium 40 positioned between the first electrical contact 64A and the second electrical contact 64B to change as shown by the lines labeled B. As illustrated by the lines labeled B, the effective area 50 of each effective length tuner 28 is about equal to the portion of the first electrical contact 64A adjacent to the array waveguide 26.

When the potential on the electrical contact adjacent to the P-type material is less than the potential on the electrical contact adjacent to the N-type material, a current flows through the light transmitting medium 40 and the index of refraction decreases. The reduced index of refraction decreases the effective length of the array waveguides 26. When the potential on the index changing element adjacent to the P-type material is greater than the potential on the index changing element adjacent to the N-type material, an electrical field is formed between the index changing elements and the index of refraction increases. The increased index of refraction increases the effective length of the array waveguide 26. As a result, the controller 30 can change from increasing the effective length of the array waveguides 26 to decreasing the effective length of the array waveguides 26 by changing the polarity on the first electrical contact 64A and the second electrical contact 64B.

Increasing the potential applied between the first electrical contact 64A and the second electrical contact 64B increases the amount of effective length change. For instance, when the effective length tuner 28 is being employed to increase the effective length of an array waveguide 26, increasing the potential applied between the first electrical contact 64A and the second electrical contact 64B further increases the effective length of the array waveguide 26. Additionally, increasing the size of the first electrical contact 64A serves to cover a larger area of the array waveguides 26 can increase the amount of effective length change although a larger potential may be required.

A12 cont'd

Each of the first electrical contacts 64A and the second electrical contacts 64B can be connected in series as shown in Figure 7A. The doped regions 66 need not extend under the electrical conductor 56 connecting the electrical contacts. Connecting the first electrical contacts 64A in series causes the amount of current flow per unit of effective area 50 of first electrical contact 64A to be about the same for each set of electrical contacts. As a result, the amount of effective length change per unit of effective area 50 is about the same for each first electrical contact 64A.

As noted above, the degree of the effective length change increases as the applied potential increases. As a result, the applied potential is controlled so as to tune the filter 10. For instance, when the effective length tuners 28 of Figure 2A include a first electrical contact 64A and a second electrical contact 64B arranged such that the total change in effective length for the j-th array waveguide 26 is $j*\Delta l$, a higher potential is needed to make the channel labeled B

appear on the output waveguide 16 than is required to make the channel labeled A appear on the output waveguide 16.

When the effective length tuners 28 include electrical contacts, Equation 2 can be used to determine the tuning range, $\Delta\lambda$, of the filter 10. In Equation 2, λ_1 is the lowest wavelength in the tuning range, Δn_E is the total change in the index of refraction of the light transmitting medium that results from the current injection or the applied electrical field change. Δn_E can be expressed as $dn_E/dN * \Delta N$ where ΔN is the total carrier density change needed for the tuning range $\Delta\lambda$ and dn_E/dN measures the change in the index of refraction of the light transmitting medium 40 that occurs per unit of carrier density change. Equation 2 illustrates that increasing the value of ΔL_{ELT} can increase the tuning range. Additionally, increasing Δn_E, dn_E/dN or ΔN can increase the tuning range.

$$\Delta\lambda = (\Delta n_E * \Delta L_{ELT} * \lambda_1) / (\Delta L) \qquad \text{Equation 2}$$

A12 cont'd

The tuning range of effective length tuners 28 that include electrical contacts can be limited by free carrier absorption that develops when higher potentials are applied between the first electrical contact 64A and the second electrical contact 64B. Free carrier absorption can cause optical loss. Increasing ΔL_{ELT} can increase the tuning range without encouraging free carrier issues. Additionally, choosing a light transmitting medium 40 with an index of refraction that is highly responsive to current or electrical fields can also improve the tuning range.

The second electrical contact 64B can have about the same width as the first electrical contact 64A as shown in Figure 7B. Alternatively, the second electrical contact 64B can have a width that is greater than the width of the first electrical contact 64A as shown in Figure 7C. The additional width of the second electrical contact 64B can help to distribute the region where the index of refraction changes more evenly through the light signal carrying region 46.

The second electrical contact 64B need not be positioned under the ridge 44 as shown in Figure 8A through Figure 8B. Figure 8A is a topview of a component 36 having first electrical contact 64A positioned over the ridges 44 of the array waveguides 26 and Figure 8B is a cross

section of the component 36 of Figure 8A taken at the line labeled A. This arrangement causes the index of refraction to be changed in the region indicated by the lines labeled B.

Figure 9A and Figure 9B show the first electrical contact 64A and the second electrical contact 64B configured to act as common effective length tuner 52 as discussed above in respect to Figure 4B. Figure 9A is a topview of a component 36 having a first electrical contact 64A extending over a plurality of the array waveguides 26 and Figure 9B is a cross section of Figure 9A taken at the line labeled A. Although the shape of the second electrical contact 64B is not illustrated, the second electrical contact 64B can have a shape that mirrors the shape of the first electrical contact 64A. The dimensions of the second electrical contact 64B need not be the same as the dimensions of the first electrical contact 64A. For instance, the second electrical contact 64B can have larger dimensions than the first electrical contact 64A while retaining a shape that mirrors the first electrical contact 64A. The doped regions 66 are formed under the entire first electrical contact 64A and the entire second electrical contact 64B.

A12 cont'd

The first electrical contact 64A has a wedge shape. Although not illustrated, one or both sides of the wedge can have a stair step shape. The stair step shape can encourage a consistent effective area 50 length across the width of the array waveguide 26.

The first electrical contact 64A and the second electrical contact 64B can also serve as a temperature controlled device. For instance, the doped regions 66 can be eliminated. When enough potential is applied between the first electrical contact 64A and the second electrical contact 64B, a current will flow through the light transmitting medium 40 and increase the temperature of the light transmitting medium 40. Accordingly, the electrical contacts can serve as a heater.

When the effective length tuners 28 include electrical contacts, the filter 10 can be controlled from calibration data. For instance, the TEC can be employed to hold the filter 10 at a constant temperature. The wavelength and/or channel that appears on the output waveguide 16 is monitored as the potential on the first electrical contact 64A and the second electrical contact 64B is changed. The generated data is used to determine a relationship between the wavelength (or channel) and the applied potential. The relationship can be expressed by a mathematical equation generated by performing a curve fit to the data. Alternatively, the relationship can be expressed in a tabular form.

During operation of the filter 10, the TEC is employed to hold the filter 10 at the temperature at which the calibration data was generated. The relationship is used to identify the potential associated with the wavelength that is desired to appear on the output waveguide 16. The effective length tuners 28 are then operated at the desired potential.

The effective length tuners 28 need not be constructed to produce a change in effective length per unit of effective area 50 that is about the same for each effective length tuner 28. For instance, the controller 30 can independently control each effective length tuner 28. The controller 30 can control the effective length tuners 28 so different effective length tuners 28 have a different change in effective length per unit of effective area 50. For instance, when the effective length tuners 28 are temperature controlled devices the controller 30 can control the effective length tuners 28 so different effective length tuners 28 have different temperatures. As a result, the constant ΔL_{ELT} need not be retained. For instance, each effective length tuner 28 can have about the same effective area 50. In order to preserve the constant ΔL, effective length tuners 28 where a larger change in effective length is needed are increased to higher temperatures than effective length tuners 28 where a lower change in effective length is needed.

A12 cont'd

When the effective length tuners 28 include sets of electrical contacts, the controller 30 can control the effective length tuners 28 so a different amount of current flows through different effective length tuners 28. As a result, the constant ΔL_{ELT} need not be retained. For instance, each effective length tuner 28 can have about the same effective area 50. However, effective length tuners 28 where a larger change in effective length is needed to preserve a constant ΔL can be operated at higher currents than effective length tuners 28 where a lower change in effective length is needed.

Please amend paragraph 134 as follows:

An effective length tuner 28 can be broken into a plurality of sub-effective length tuners 74 as shown in Figure 11A. The electrical conductors 56 connect the sub-effective length tuners 74 in series. Breaking the effective length tuners 28 into smaller portions can increase the isolation between adjacent array waveguides 26 because each sub-effective length tuner 74 affects a smaller region of the component 36 that does an effective length tuner 28. Although each of the array waveguide 26 is shown as having the same number of sub-effective length tuners 74, different array waveguides 26 can have different numbers of effective length tuners

A13

A13 cont'd

28. For instance, the shortest array waveguides 26 can have a single sub-effective length tuner 74.

Please amend paragraph 139 as follows:

A14

For the purposes of illustration, the second group 76B is shown as inverted relative to the first group 76A. When the first group 76A is operated so as to increase the temperature, the effective length of the array waveguides 26 increases causing the effective length differential, ΔL, to increase. When the second group 76B is operated so an electrical current flows between the first electrical contact 64A and second electrical contact 64B, the effective length of the array waveguides 26 decreases. Because the second group 76B is inverted relative to the first group 76A, decreasing the effective length of the array waveguides 26 also causes the effective length differential to increase. As a result, when the first group 76A and the second group 76B are concurrently operated as described, they can increase the tuning range by acting together to increase the effective length differential.

Please amend paragraph 141 as follows:

A15

Although not illustrated, the effective length tuners 28 can include a temperature control device 54 positioned over an electrical contact. This arrangement can provide an increased tuning range over what could be achieved with either type of effective length tuner 28 alone. When the temperature controlled device is a resistive heater, an electrical insulator can be positioned between the electrical contact and the resistive heater.

Please amend paragraphs 161 and 162 as follows:

A16

Any doped regions 66 to be formed on the ridge 44, adjacent to the ridge 44 and/or under the ridge 44 can be formed using techniques such as impurity deposition, implantation or impurity diffusion. Electrical contacts can be formed adjacent to the doped regions 66 by depositing a metal layer adjacent to the doped regions 66. Any metal layers to be used as temperature control devices 54 can be grown or deposited on the component 36. Doped regions 66, electrical contact, electrical conductors 56, pads 58 and/or metal layers can be formed at various points throughout the method and are not necessarily done after the last etch. Suitable electrical conductors 56 and pads 58 include, but are not limited to, metal traces.